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Electric field-based technologies for valorization of bioresources

Renewable Energy Directive (2009/28/EC) has targeted for the EU to have 20% of its final energy consumption provided by renewable sources by 2020. Moreover, legislation establishes that biofuels must be produced by environmentally friendly processes. In this context, biorefinery development is considered an appropriated strategy for the suitable use of renewable sources. The biorefinery is based on the raw materials processing for bio-based products, chemicals, and fuels manufacturing as an alternative to the petroleum refinery.

Lignocellulosic biomass, the most abundant source of biomass, is composed of three major components namely cellulose, hemicellulose and lignin. However, several other sources of biomass and in particular agro-food and forestry wastes and surplus are key elements on the development of biorefineries. They represent a rich supply of valuable nutrients and functional biomolecules bringing together the potential needed to be used as raw material for the development of new food products, and being thus kept within the food supply chain for human nutrition, or to be incorporated in other value chains such as cosmetics, pharmaceuticals or bioplastics. This is of particular relevance as it is estimated that, in 2012, 12.5 % of the global population was undernourished this demanding for a rational use of land, energy, chemicals/fertilizers and water. Therefore, food security, climate changes, health, energy and sustainability issues jumped into the last decades' political agenda and public consciousness.

Although processing of the biomass has been receiving a great deal of attention in particular due to the interest on the production of 2nd generation biofuels, there are several issues that need to be optimized, in particular the development of more efficient technologies for their fractionation. This becomes more relevant as the use of agro-food and forestry wastes is considered. The high number of added value compounds existing in these materials, in some cases in low concentrations, demands the development and implementation of fractionation strategies that will allow for an efficient valorization of the available biomass. The successful re-utilization of these streams and extractable biomolecules will always require a judicious intervention of strategies and processing technologies for safety and functional enhancement. Moreover the fractionation strategies to be developed must be "green" and environmental friendly as well as economically feasible.

The achievement of the goals established for the development of a circular economy and a biorefinery demands not only the rethinking of existing production methods and strategies, but the development of new approaches and technological solutions is also a fundamental requirement.

Among the novel and emergent bioprocess technologies, electro-technologies, which are based on the application of electric current in biomaterials with technological purposes have been receiving an increasing interest.

The application of an EF on a biological or bio-based system will result on dissipation of heat, since the system will act as a semi-conductor. Often designated as Ohmic Heating (OH), this is explained by the Joule effect and provides a fast and homogeneous heating rate along with high energetic efficiencies. Other consequence of the EF presence is electroporation, as the exposure of cells to an external EF results on the formation of a transmembrane potential. Some advantages have been recognized on the use of electrotechnologies for bioresources valorization as they may promote stabilization of the biomaterials, endorse or

enhance extraction and diffusion of compounds, assist in separation and fractioning, among others.

The application of an EF is classified according to type of electric flow (i.e. direct or alternating current), application in pulses or not, electric field strength (voltage applied by the section length), extension of heat deposition, among others. High voltage electrical discharges (HVED), Pulsed electric field (PEF) and Moderate electric fields (MEF), also known as Ohmic heating (OH) are the EF based technologies being currently developed for the fractionation of the biomass/extraction of bioactive compounds.

In the last years, MEF and the corresponding ohmic heating (OH) have been gaining an increasing interest for extraction processes. OH presents high heating rates with a precise temperature control allowing mild processing and preserving nutritional, functional and structural properties. Heat is generated inside the material to be heated (Joule effect), the heating process does not depend on heat transfer between phases and interfaces, allowing uniform heating and an extremely rapid heating rate. Furthermore, it also allows heating of large particulates and fluids at comparable rates, as long as their conductivities remain similar. Moreover, the process has high energy conversion efficiencies resulting in lower operational costs and in a more environmentally-friendly system.

Results describing application of OH on the extraction of bioactive compounds will be presented and challenges and perspectives on the future of the application of OH will be discussed aiming at the development of more sustainable biorefineries.